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The Gomphidae of Algeria and the Maghreb: status, ecology and conservation (Insecta: Odonata)

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A survey of the Gomphidae of Algeria and the Maghreb was carried out during the period 2013–2014. Sampling of eight main wadis across northern Algeria was undertaken and adults and exuviae were recorded. The survey yielded six species of Gomphidae. Among these, we report on the rediscovery of the Critically Endangered *Lindenia tetraphylla* in Algeria, recorded in the nineteenth century and deemed to have been extinct after an absence of more than a century and a half. An exuvia was collected at Wadi Saoura, which constitutes the first proof of the breeding of this species in Algeria and the third record for North Africa. We also recorded a pale form of *Onychogomphus uncatus*, morphologically distinct from typical Moroccan and European phenotypes, suggesting some degree of subspeciation and inviting further taxonomical investigations of the genus *Onychogomphus* in North Africa. Due to increasing water demand, Gomphidae and their habitats are under great pressure in the Maghreb. Specific threats and conservation measures are discussed.

Keywords: Algeria; anthropogenic impact; ecology; Gomphidae; Odonata; *Onychogomphus uncatus*; *Lindenia tetraphylla*; niche partitioning; North African wadi; vicariance

Introduction

Odonata have complex life cycles with discrete life stages spent in distinct habitats (Corbet, 1999). Dragonfly larvae are relatively large obligate predators which may have a considerable impact on community structure of freshwater ecosystems (Woodward & Hildrew, 2001, 2002). Among Odonata, gomphids are an important component of the biota of running waters and their numbers and diversity are considered a reliable indicator of a healthy fluvial system (Ferreras-Romero, Márquez-Rodriguez, & Ruiz-Garcia, 2009). The need to update our knowledge of the Gomphidae of Algeria is clear as some species have not been recorded since the nineteenth or early twentieth centuries. Their recent assessment by IUCN was a "best of a bad job" undertaking, as records were mostly outdated while North African habitats are undergoing fast changes (Samraoui et al., 2010). Over the last 15 years, additions to the Maghrebian odonate fauna have been accumulating steadily (Boudot, 2008; Juillerat & Monnerat, 2009; Korbaa, Ferreras-Romero, Bejaoui, & Boumaza, 2014; Samraoui & Alfarhan, 2015; Samraoui,

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Weekers, & Dumont, 2003), culminating with the recent discovery of a species new to science in Morocco, *Onychogomphus boudoti* (Ferreira et al., 2014). This highlights the need for more surveys of the Maghrebian odonate fauna. This survey aims at improving our knowledge of the Gomphidae of Algeria and the Maghreb by (1) assessing their status, (2) identifying environmental factors driving their spatial and temporal distributions, and (3) documenting specific threats to their habitats.

Methods

Eight wadis were sampled across Algeria, stretching from Wadi Kébir-Est near the Tunisian border to Wadi Saoura, close to Morocco (Figure 1, Table 1). Six wadis (Seybouse, Sebaou, Isser, El Harrach, Tafna, and Saoura) were sampled monthly from April to October 2013. A series of 4–10 stations was sampled along the course of each wadi. Kébir-East (2013 and 2014) and Chioukh, Mount Edough (2014) were sampled sporadically. A series of 12 abiotic descriptors

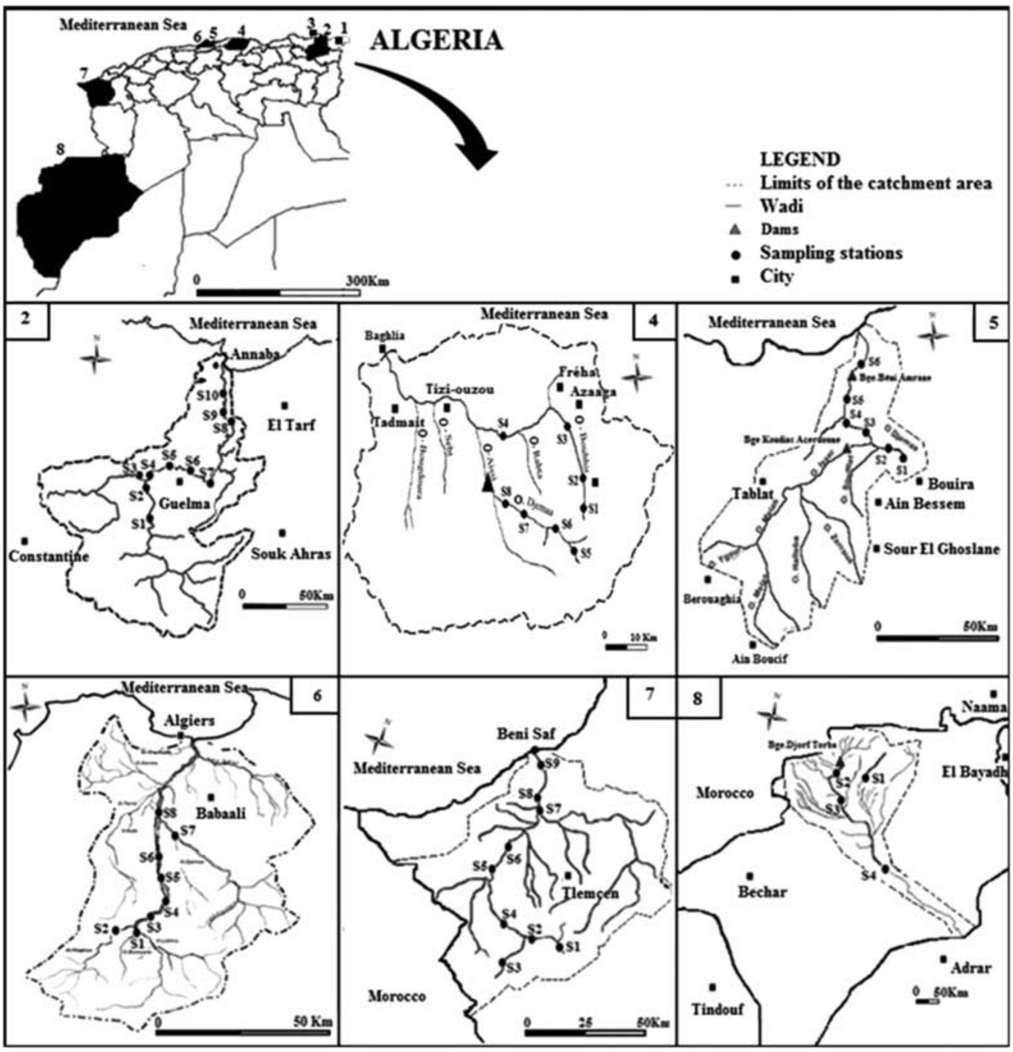

Figure 1. Map of Algeria displaying the studied watershed and sampled localities; Locality codes in Table 1.

Table 1. GPS coordinates and altitude of localities where Gomphidae were recorded. Negative values are used for western longitudes. Record of *O. costae* at Kébir-Est dates from 1993 (Benchalel & Samraoui, 2012). Code is locality code from Figure 1.

Watershed	Locality	Code	Species	Latitude	Longitude	Alt. (m)
Mount Edough						
	Wadi Chioukh		*O. uncatus*	36° 55′ 32.5″	7° 40′ 58.9″	700
Kébir-Est						
	Kébir-Est		*P. genei*, *O. costae*	36° 46′ 03″	8° 21′ 52″	25
Seybouse						
	Chihani	S8	*G. lucasii*, *O. costae*	36° 39′ 13″	7° 46′ 57″	26
	Mellah		*O. costae*	36° 27′ 32″	7° 42′ 56″	87
	Halia	S7	*G. lucasii*, *O. costae*	36° 24′ 49″	7° 36′ 40″	144
	Nador	S6	*O. costae*	36° 27′ 33″	7° 34′ 18″	187
	Zimba		*O. f. unguiculatus*	36° 27′ 49″	7° 29′ 15″	205
	Héliopolis		*G. lucasii*	36° 30′ 48″	7° 27′ 02″	259
	El Fedjoudj	S5	*G. lucasii*	36° 28′ 24″	7° 23′ 07″	221
	Medjez Amar	S2	*G. lucasii*, *O. costae*	36° 26′ 34″	7° 18′ 39″	287
	Aïn Makhlouf	S1	*G. lucasii*, *O. costae*	36° 14′ 27″	7° 18′ 37″	599
	El Aar		*O. f. unguiculatus*	36° 13′ 34″	7° 19′ 11″	609
	Cheniour		*G. lucasii*	36° 14′ 52″	7° 20′ 36″	742
	Krab		*G. lucasii*	36° 07′ 12″	7° 32′ 47″	788
Isser						
	Wadi Djamaa	S1	*O. f. unguiculatus*	36° 26′ 01″	3° 50′ 50″	371
	Wadi Djamaa	S2	*O. f. unguiculatus*	36° 28′ 08″	3° 44′ 46″	328
	Wadi Isser	S3	*O. f. unguiculatus*	36° 31′ 34″	3° 40′ 45″	179
	Wadi Isser	S5	*O. f. unguiculatus*	36° 37′ 21″	3° 34′ 49″	72
Sebaou						
	Chaïb	S4	*O. f. unguiculatus*	36° 42′ 14″	4° 10′ 35″	100
	Djemaa El Had	S7	*O. f. unguiculatus*	36° 35′ 50″	4° 12′ 04″	360
El Harrach						
	Magtaa Lazrag	S1	*O. f. unguiculatus*	36° 27′ 53″	3° 00′ 55″	220
	Hammam Melouène	S4	*O. f. unguiculatus*	36° 29′ 22″	3° 03′ 07″	158
	Bougara	S6	*O. f. unguiculatus*	36° 32′ 06″	3° 03′ 45″	92
	Baba Ali	S7	*O. f. unguiculatus*	36° 36′ 50″	3° 04′ 29″	29
	Baba Ali	S9	*O. f. unguiculatus*	36° 37′ 33″	3° 03′ 45″	25
Saoura						
	Djorf Torba	S2	*L. tetraphylla*, *O. costae*	31° 30′ 34″	–2° 46′ 25″	687
Tafna			No records of Gomphidae	34° 44′ 13″	–1° 34′ 57″	

were measured: water temperature (WatT in °C), air temperature (AirT in °C), dissolved oxygen ($O2$ in mg l^{-1}), per cent dissolved oxygen (O2per in %), pH, redox potential (Elec in mV), salinity (Sal in PSU), conductivity (Cond in mS cm^{-1}), speed (Speed in cm s^{-1}), bed width (Width in m), water depth (Depth in m) and altitude (Alt in m).

Adults and exuviae were recorded and identified using various keys (Dijkstra & Lewington, 2006; Gerken & Sternberg, 1999; Grand & Boudot, 2006). A principal component analysis (PCA) was performed on presence/absence data (21 stations/12 environmental variables and four species) using the package FactoMineR (Lê, Josse, & Husson, 2008). Data analyses and graphs were carried out using R (R Development Core Team, 2014).

Results

The present survey has yielded six species of Gomphidae (Figures 2, 3; Table 1). One species, the Critically Endangered *Lindenia tetraphylla*, recorded in the nineteenth century in eastern Algeria and deemed to be regionally extinct, was rediscovered in the western part of Algeria. Another species, tentatively assigned to *O. uncatus*, may represent either simply a pale phenotype of the latter or an undescribed taxon.

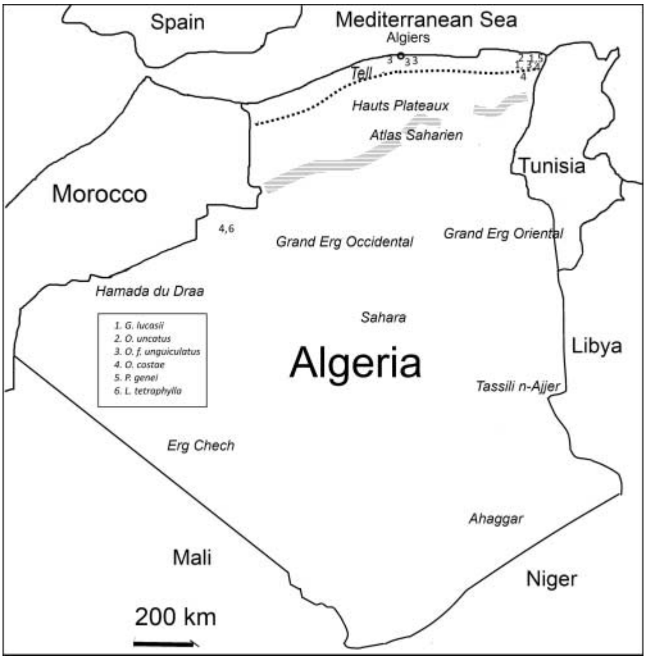

Figure 2. Map of Algeria with recorded localities of Gomphidae (inset).

Species data

1. *Gomphus lucasii* Selys, 1849
Status. VU.
Flight period. April–June.
Locality. Seybouse.

Previous localities. Rhummel, Oubeïra (Selys, 1849), Oran (Selys & Hagen, 1850, 1857), Orléansville (now Chlef) (Selys, 1871; Selys & Hagen, 1857), between Blida and Médéa (Kolbe, 1885), Constantine (McLachlan, 1897), Rhummel (Martin, 1901), Teniet el Had, Sebdou (Morton, 1905), Constantine, Oubeïra (Martin, 1910), Hammam Bou Hadjar (Schmidt, 1936), Numidia (Samraoui & Menaï, 1999).

Comments. This species is present from sea-level to foothills (600 m), but is particularly abundant at lower altitudes.

2. *Onychogomphus uncatus* (Charpentier, 1840)
Status. LC.
Flight period. July.
Locality. Wadi Chioukh (Séraïdi, Mount Edough).

Previous localities. Teniet el Had, Sebdou (Morton, 1905), Rhummel (Martin, 1910), Ighzer Temda (Lacroix, 1925), Tlemcen (Schmidt, 1936), Numidia, Mechroha (Samraoui & Menaï, 1999).

Comments. On 29 July 2014, two males of *O. uncatus* were recorded at Wadi Chioukh (Mount Edough) but only one of them could be collected. Both males were similar in having a pale thorax and differed enough from typical *O. uncatus* in their black/yellow pattern to warrant a

Figure 3. Photographs of (a) *Gomphus lucasii* (Wadi Seybouse, 2014); (b) *Lindenia tetraphylla* (Hijaz, Saudi Arabia, 2014); (c) *Onychogomphus forcipatus unguiculatus* (Wadi Seybouse, 2013); (d) immature *O. costae* (Wadi Seybouse, 2014).

brief description (Figure 4a, b) to stimulate further taxonomical investigations. The vertex is all-black, but the yellow "collar" is more narrowly interrupted in the middle by black. These males lack extensive confluent black lines on the side of the thorax, a feature which is reminiscent of *O. forcipatus unguiculatus* and, to a lesser extent, of *O. lefebvrii*. They differ in structure from the former by their "*O. uncatus*-type" epiproct, just semi-circular and missing any differentiated structure at the apex, and from the latter by the presence of a sub-basal tooth and a darker pterostigma. These males are clearly distinct from *O. boudoti*, recently described from Morocco (Ferreira et al., 2014) but more specimens are needed to confirm its distinctiveness from the usual European and Moroccan specimens of *O. uncatus*. So pending the collection of more specimens, the Edough taxon is assigned to *O. uncatus*, a species to which it is undoubtedly closely related. Males were settled on the ground on the shore of a mountain stream with a moderate flow. Habitat was shared mainly with patrolling *Boyeria irene, Aeshna cyanea* and *A. mixta* (Samraoui & Alfarhan, 2015).

3. *Onychogomphus forcipatus unguiculatus* (Vander Linden, 1820)
Status. LC.
Flight period. June–July.
Locality. Seybouse, El Harrach, Sebaou, Isser.

Previous localities. Algeria (Selys, 1849), between Médéa and Blida (Kolbe, 1885), Constantine (McLachlan, 1897), Sebdou (Morton, 1905), Constantine (Martin, 1910), Hammam Bou Hadjar (Schmidt, 1936), Numidia, Jijel (Samraoui & Menaï, 1999).

Figure 4. Side view of the Edough Onychogomphus assigned to *O. uncatus* (a). Dorsal view of the same specimen (b).

Comments. Relatively common in the centre of Algeria, but confined to a few sites in the east. At Wadi Seybouse, the species was more abundant at medium altitudes.

4. *Onychogomphus costae* Selys, 1885
Status. NT.
Flight period. May–October. Pairs in copula were noted in June and August.
Locality. Seybouse, Saoura.

Previous localities. Oran (Selys, 1871), Biskra, Constantine (McLachlan, 1897; Martin, 1901, 1910), Hammam Bou Hadjar (Schmidt, 1936), Bou Faadid, Reggan, Aoulef (Reymond, 1952), Numidia (Samraoui & Menaï, 1999).

Comments. A species endemic to the Maghreb and the Iberian Peninsula. It is relatively common in northeast Algeria but appears to be less frequent further west. Our record, based on a single exuvia, confirms that the species may penetrate the Sahara. The old record of *Paragomphus costae* by Reymond (1952), ascribed to *P. genei* by Boudot et al. (2009), is thus upheld by this new finding. The same applies to the Tunisian record at Tozeur by Campion (1914), considered doubtful by Jödicke, Arlt, Kunz, Lopau, and Seidenbusch (2000).

5. *Paragomphus genei* (Selys, 1841)
Status. LC.

Flight period. October, but may be found from April to October (Samraoui & Menaï, 1999).

Locality. Kébir-East watershed, Brabtia, close to Wadi Bouarroug.

Previous localities. Oubeïra, Biskra (McLachlan, 1897), Biskra (Martin, 1901, 1910; Ris, 1909–1913), Oubeïra (Martin, 1910), Algiers (Ander, 1929), Tassili n'Ajjer (Dumont, 1979), Numidia, Laghouat, El Goléa, Adrar, Timimoun (Samraoui & Menaï, 1999).

Comments. Records under the synonyms of *O. hageni* Selys and *Mesogomphus hageni* Selys have been assigned to *P. genei*. Emergences seem to spread from May to November. A mass emergence was witnessed at Wadi Kébir-Est in September 1993, but the locality was heavily degraded in 2014 and the species was absent. An adult was recorded in a maquis near El Kala in October 2014.

6. *Lindenia tetraphylla* (Vander Linden, 1825)
Status. CR.
Flight period. May.
Locality. Saoura.

Previous localities. La Calle (Selys, 1849).

Comments. The species was first recorded in Algeria in the nineteenth century and was deemed extinct (Boudot et al., 2009). A population was discovered in nearby Tunisia (Kunz & Kunz, 2001). An exuvia was found downstream of the Djorf Torba reservoir, proof of the reproduction of the species in western Algeria.

Multivariate analysis

The range of occupied habitats by the recorded species exhibited significant variation of physicochemical variables (Figures 5, 6). Dimension reduction was performed using PCA. Four components, representing 76.4% of the total variance, were retained (Figure 7). The first component (29.7% of the inertia) is associated with high pH and large bed width. Habitats having these characteristics are linked to *G. lucasii*, *O. costae* and *L. tetraphylla* (Figure 7). This first component opposes habitats with high depth of water, occupied by *O. f. unguiculatus*. The second component (22.2% of the inertia) is associated with dissolved oxygen and temperature. The third component (14.2% of the inertia) opposes both *G. lucasii* and *O. costae* to *L. tetraphylla* on the basis of salinity and altitude (Figure 8). The fourth component (10.2% of the inertia) is of minor importance and separates sites on the basis of water current (Figure 8).

Discussion

Status

Six species, representing four genera (*Gomphus*, *Lindenia*, *Onychogomphus* and *Paragomphus*), are believed to exist in Algeria and they all have been recorded during this survey. A further two species are cited in the literature:

(1) *Onychogomphus lefebvrii* (Rambur, 1842) was reported by Martin (1910) from Wadi Rhummel and Biskra. These records will be discussed in the light of the new finding of the pale form of *O. uncatus* from Mount Edough.
(2) *Gomphus simillimus maroccanus* Lieftinck, 1966, of which the taxonomic status deserves further investigations (Dumont, 1972; Boudot et al., 2009), recorded in Algeria (Brauer, 1876 in Le Roi, 1915), at El Guerra and Wadi Seybouse (Martin, 1910), and at Tlemcen (Schmidt, 1936). The former three records are now considered to pertain to *G. lucasii* (Samraoui & Menaï, 1999) but not the last one, as in the same paper dealing with

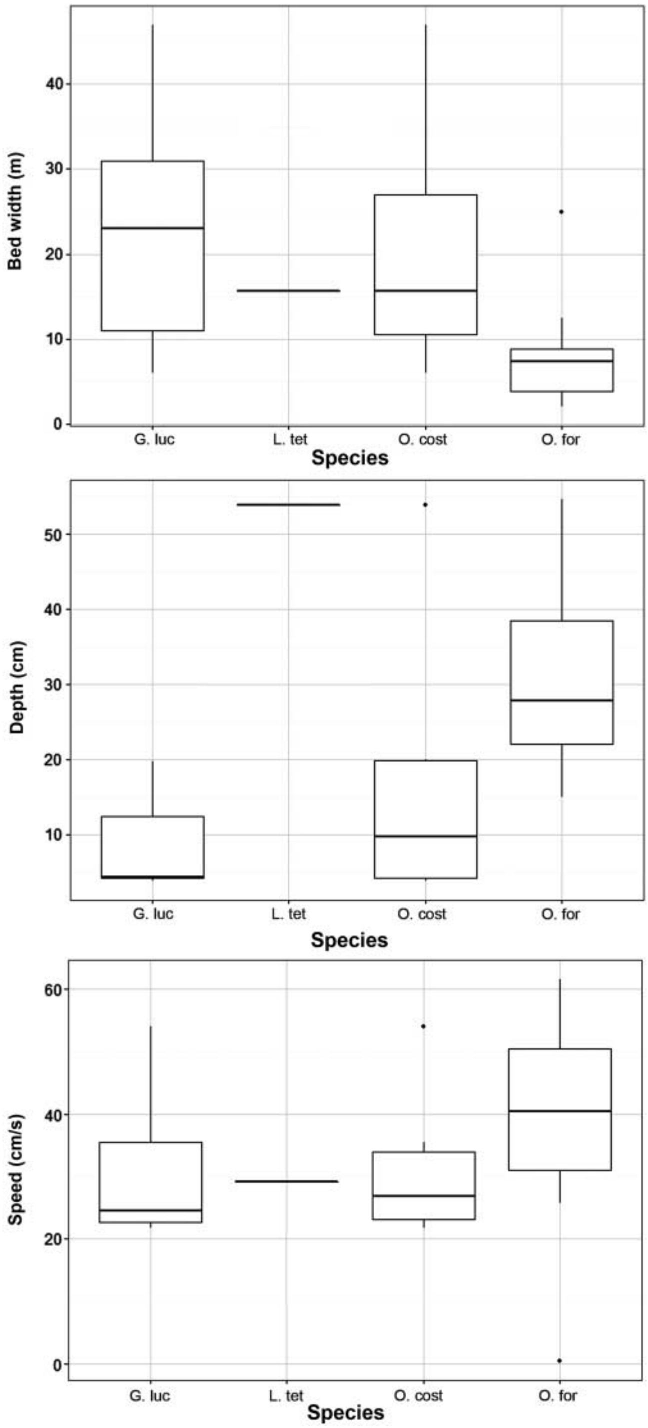

Figure 5. Extent of variation in bed width, depth of water and current speed of habitats occupied by *G. lucasii* (Gluc), *L. tetraphylla* (Ltet), *O. costae* (Ocost), and *O. forcipatus* (Ofor).

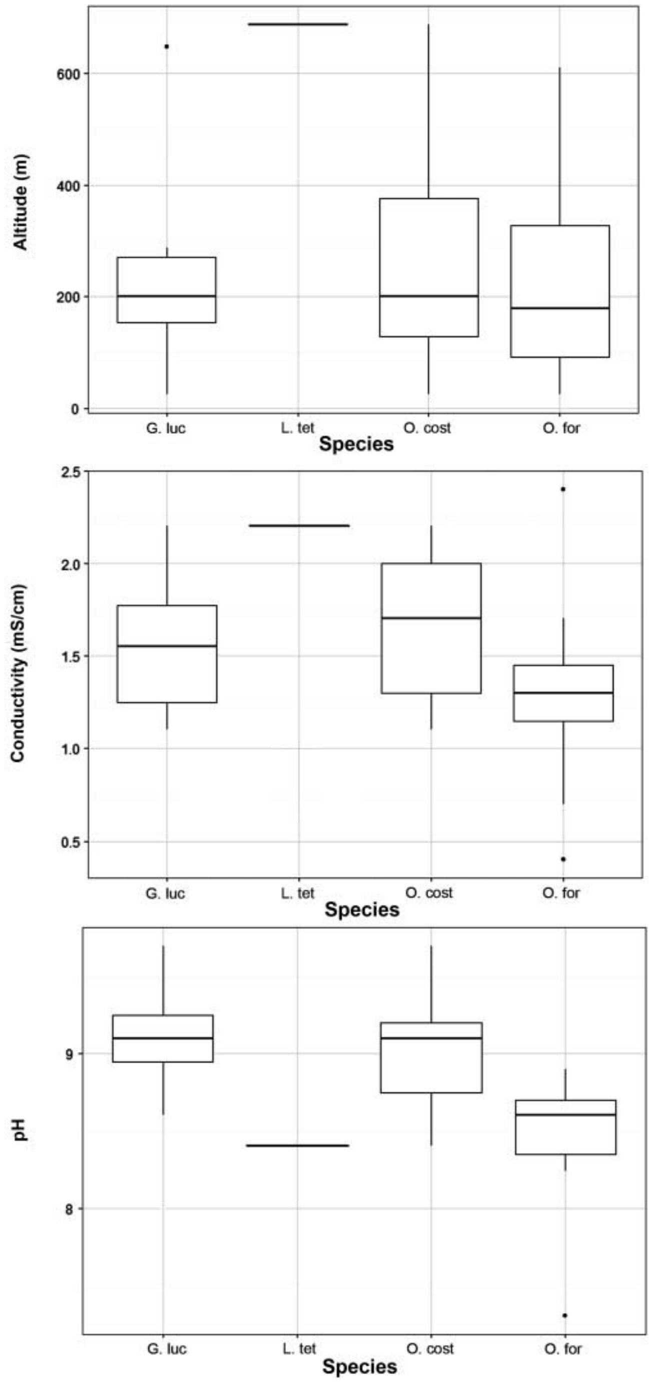

Figure 6. Extent of variation in altitude, water conductivity and pH of habitats occupied by *G. lucasii* (Gluc), *L. tetraphylla* (Ltet), *O. costae* (Ocost), and *O. forcipatus* (Ofor).

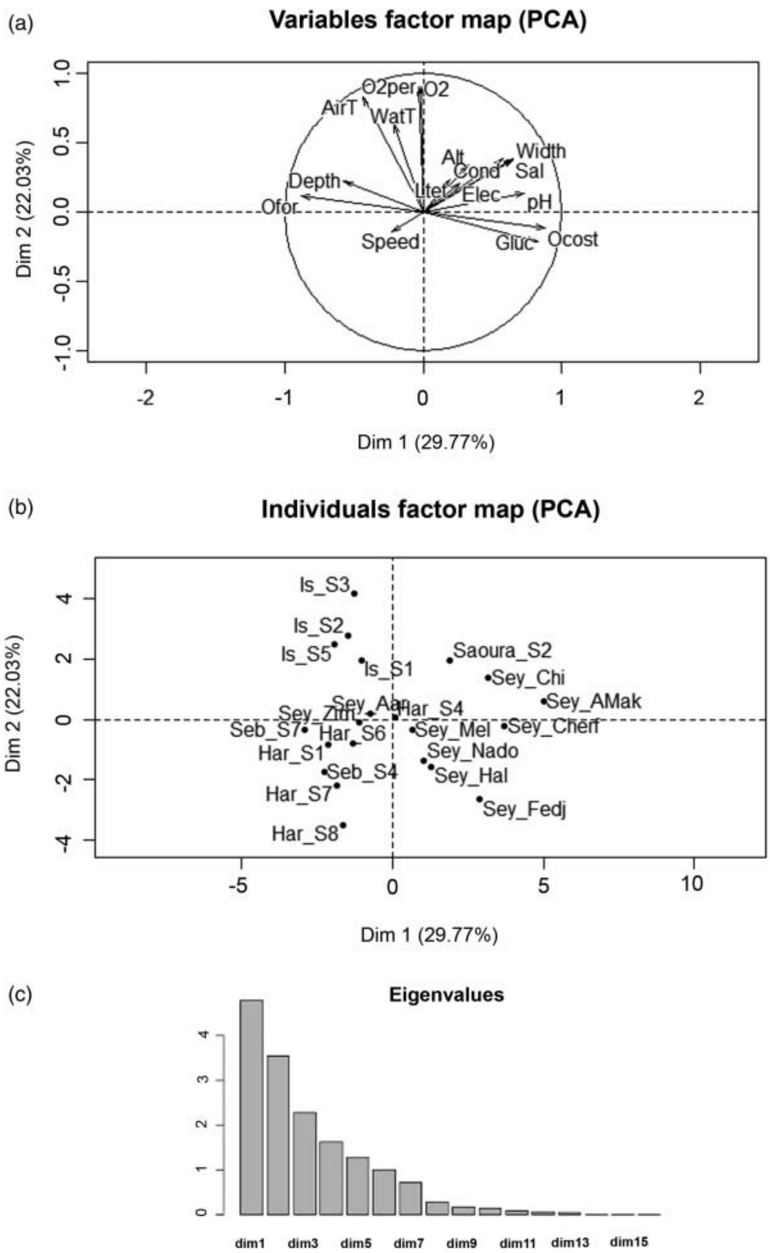

Figure 7. First two principal components of (a) variable factor map and (b) individual factor map. (c) Scree plot.

larvae/exuviae of Gomphidae, the author listed *G. lucasii* at Hammam Bou Hadjar and *G. simillimus* (*maroccanus*) at Tlemcen, and therefore discriminated the two taxa. However, the validity and distribution of *G. simillimus maroccanus* in the Maghreb remain an open question.

The newly described *O. boudoti*, a Critically Endangered species, is endemic to Morocco and is deemed to be facing a high risk of global extinction (Ferreira et al. 2014).

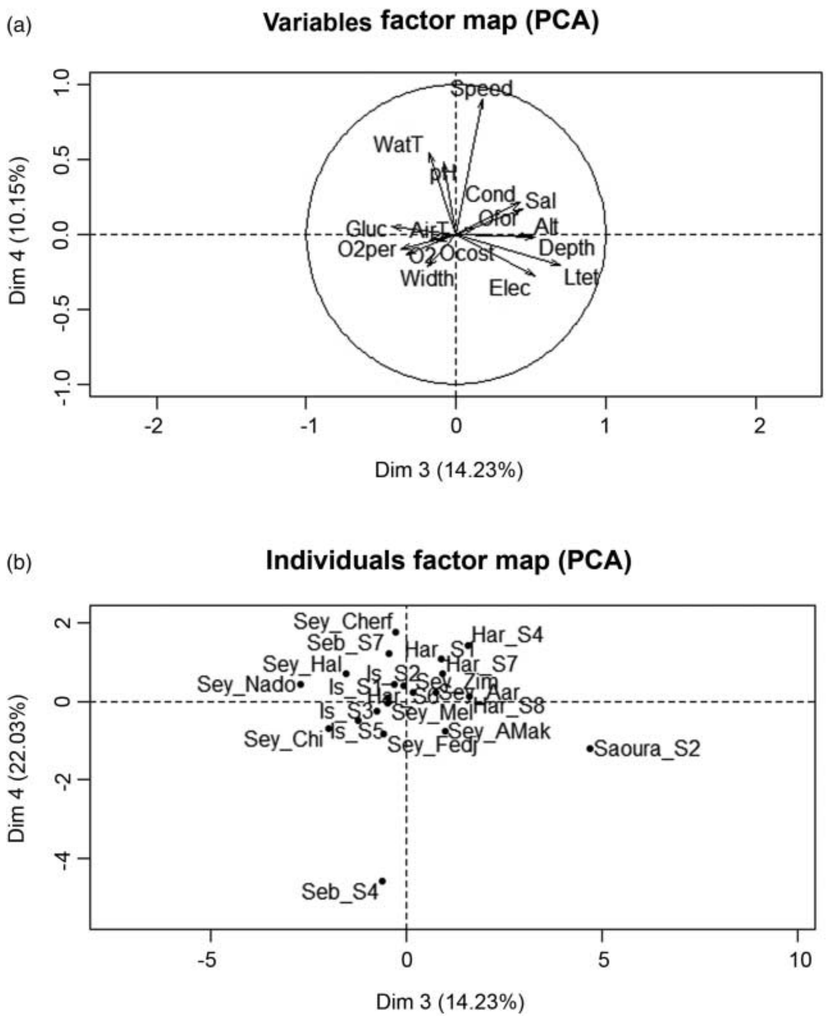

Figure 8. Third and fourth principal component of (a) variable factor map and (b) individual factor map.

The pale form of **O. uncatus** *and the* **O. lefebvrii** *enigma*

In North Africa and southern Spain, *O. uncatus*, not unlike *A. cyanea* (Ferreras-Romero, Dolores Atienzar, & Corbet, 1999; Samraoui & Corbet, 2000a), is confined to mountain streams whereas in other parts of Europe, the species may occupy also lowland rivers and canals (Suhling, 1996). Its status in North Africa is listed as Least Concern on the IUCN North African Red List (Samraoui et al., 2010) but this evaluation rests on the abundance of the species in Morocco and the range believed to span Morocco, Algeria and Tunisia. Past records of *O. uncatus* from Algeria are old (Lacroix, 1925; Martin, 1910; Morton, 1905), misidentified (Khelifa et al., 2011) or based on larvae (Benchalel & Samraoui, 2012; Samraoui & Corbet, 2000a).

The presence of a pale form in Mount Edough points to the need to re-evaluate the taxonomic status of the genus in North Africa and to draw conservation consequences. We may speculate that early in the twentieth century, Gadeau de Kerville may have collected the pale form of *O. uncatus* (the Edough phenotype) in Tunisia which was then misidentified by Martin as *O. lefebvrii* (Gadeau de Kerville, 1908). This latter species is an Asiatic species ranging from the

Middle East to Afghanistan (Boudot et al., 2009) and it is unlikely that it ever existed in Algeria (Samraoui & Menaï, 1999) or Tunisia (Jödicke et al., 2000) and even in Egypt, its so-called "type locality". A few years later, Martin (1910) collected in Algeria the same pale phenotype of *O. uncatus*, which he again misidentified as *O. lefebvrii*. There is thus an urgent need to check Martin's collection to evaluate these speculations.

Lindenia tetraphylla in North Africa

For decades, *L. tetraphylla* had been one of the least familiar odonates of the Palearctic region and was known only from a few specimens (Schorr, Schneider, & Dumont, 1998). New data are now accumulating (Boudot, 2014; Boudot et al., 2009; De Knijf, Vanappelghem, & Demolder, 2013; Kulijer, De Knijf, & Franković, 2013; Lopau, 2010; Wildermuth & Martens, 2014). The glaring gaps in our knowledge of its breeding habitats with a suggested dichotomy in the use of stagnant waterbodies and running waters in the west and in the east of the species' range, respectively, are gradually being filled in (Popova, 1997). This nomadic species is well adapted to arid and semi-arid regions (Schneider, 1988; Schröter, 2011) as it breeds in waterbodies exhibiting a wide range of succession, salinity and temperature (Busse, 1993; Karaman, 1979; Krupp & Schneider, 1988). However, its larval habitat deserves further investigations (Boudot, 2014; Brochard & van der Ploeg, 2013).

The previous and only record from Algeria dates from the nineteenth century when Lucas collected three females near Lake Oubeïra, in northeast Algeria (Selys, 1849). With the old Spanish records from the Valencia province, the new Algerian record represents one of the most western point of the species' range (Boudot et al., 2009) and may reflect a recent westward expansion in Algeria either due to climate change or, more likely, the creation of new habitats like dams and reservoirs. Due to the lack of field investigation in the Saoura valley since 1990 (Samraoui & Menaï, 1999), it is impossible to know the date of settlement of this species in the locality considered. Considered as an Iranian element (Lohmann, 1981), *L. tetraphylla* has a similar distribution pattern as another Euroasiatic species, *Selysiothemis nigra* (Vander Linden, 1825), also found in arid and semi-arid regions (Schneider, 1981; Schorr et al., 1998). Both species have scattered populations in the western Mediterranean and both seem to be extending their range in North Africa (Boudot et al., 2009). However, this expansion is controversial as such apparent changes in ranges may be due to increasing field investigations. Also, their overall worldwide range does not appear to expand northwards significantly, at least in the west Mediterranean but perhaps also in southwestern Asia according to the paucity of ancient field investigations in parts of this area (Boudot, pers. comm.). In recent years, *L. tetraphylla* has frequently been recorded after an apparent decrease in various areas of southern Europe like the Balkans and Italy (Boudot, 2014; Brochard & van der Ploeg, 2013; Gashtarov & Beshkov, 2010; Hardersen & Leo, 2011; Stille, Stille, & Schröter, 2014; Utzeri, Belfiore, & Peels, 2006) and North Africa (Kunz & Kunz, 2001), with self-sustaining populations attested in several regions (e.g. Boudot et al., 2009). This recent increase in a near constant range is largely ascribed to an increase in available man-made habitats (e.g. Boudot, 2014; Brochard & van der Ploeg, 2013), an increase in field investigations (e.g. Skvortsov & Kuvaev, 2010) and an increase in standard scientific publications.

Ecology

Biological communities are structured by the environmental conditions of their habitats, described as habitat templets (Southwood, 1977). Thus, a good knowledge of the many physical and biological factors that may determine the abundance and spatial distribution of Odonata along the river continuum (Vannote, Minshall, Cummins, Sedell, & Cushing, 1980) is essential.

The larva is considered the most influential stage in the life cycle of Odonata (Corbet & Brooks, 2008; McPeek, 2008). Gomphid larvae are burrowers that ambush prey and evade predators while buried in the sediment (Corbet & Brooks, 2008; Suhling & Müller, 1996). An important ecological driver of gomphid larvae distribution is the substrate (Leipelt & Suhling, 2001; Suhling, 1994; 1996). However, the adult stage, through site selection and dispersal, may also shape population dynamics (Remsburg, 2011).

Although of a preliminary nature and constrained by a small sample size, our exploratory analysis identifies potential environmental factors that may separate Algerian Gomphidae. Three species (*O. uncatus*, *P. genei*, and *L. tetraphylla*) were only recorded once, but they clearly differed from the other gomphids on the basis of habitats. The former occupies mountainous streams whereas the latter two species, which are able to breed in coastal and inland standing waterbodies, are more frequent in arid and semi-arid regions. *Paragomphus genei* breeds in sandy parts of wadis with residual pools and sluggish current (Benchalel & Samraoui, 2012). A striking similarity is found in the habitat partitioning of *G. lucasii* and *O. forcipatus unguiculatus* in Algeria compared to that of *G. pulchellus* and *O. forcipatus unguiculatus* in southern Spain (Ferreras-Romero & García-Rojas, 1995). In Spain, these two latter species are semivoltine and display some form of altitudinal separation by occupying different parts of the same river channel (Ferreras-Romero & García-Rojas, 1995). Likewise, at Wadi Seybouse where they co-occur, *G. lucasii* is found more often in the lower reaches of the wadi and *O. forcipatus unguiculatus* is more frequent in the middle and upper parts. Another shared similarity between the two gomphid pairs across the Mediterranean is that they may share the same life histories. *Gomphus pulchellus* is a "spring species" (or type-1, *sensu* Corbet, 1999) in Spain, like *G. lucasii* in Algeria, whereas *O. forcipatus unguiculatus* behaves as a "summer species" (or type-2, *sensu* Corbet, 1999) in both countries (Ferreras-Romero & García-Rojas, 1995; this study). Thus, there is a remarkable convergence in the life histories of *G. lucasii* and *G. pulchellus*, which may be regarded as vicariant species.

Spatial partitioning is not the only mean of coexistence in local gomphids. *Gomphus lucasii* and *O. costae*, which often share the same habitats, have distinct flight periods. The very long flight period of *O. costae* is reminiscent of that of *Anax imperator* in Britain (Corbet, 1957), which exhibits splitting larval cohorts: semivoltine individuals emerging early in the season as in "spring species" and univoltine individuals with fast development emerging later in the season as in "summer species". The suggested life history pattern of *O. costae* in Algeria is supported by studies in southern Spain (Cano-Villegas & Ferreras-Romero, 2005). This temporal partitioning which may ease competition is exhibited by many congeneric Mediterranean odonates (Ferreras-Romero & García-Rojas, 1995; Samraoui, 2009; Samraoui & Corbet, 2000b).

Conservation

The alarming status of freshwater species in North Africa (Riservato et al., 2009; Samraoui et al., 2010) is intimately associated with explosive demography and urbanization (Tabutin, Vilquin, & Biraben, 2002), combined with the increasing water demands of agriculture, industry development and domestic use (Benoit & Comeau, 2005). The lack of sewage treatment combined with human encroachment has led to pollution reaching a critical point. The proliferation of dam construction to meet the heavy demand for water and the lack of law enforcement against gravel extraction in rivers bed has worsened the water quality of most wadis in North Africa and the Middle East (Jödicke, Boudot, Jacquemin, Samraoui, & Schneider, 2004; Schneider & Schneider, 2010). Global warming may exacerbate the situation but may prompt northern African countries to take steps towards a rational management of water resources.

This survey is of a preliminary nature and further investigations, involving a greater array of wadis, are required. Combined sampling of adults and exuviae proved worthwhile in the present

study as Gomphidae are strong flyers and adults may easily evade detection (Brochard & van der Ploeg, 2013; Raebel, Merckx, Riordan, Macdonald, & Thompson, 2010). We clearly need more surveys and systematic monitoring to strengthen our knowledge of the status of Maghrebian Odonata and improve our understanding of the processes that regulate their abundance and distribution. We also need to enforce prompt and effective conservation measures to avert threats that imperil their survival (Clausnitzer et al., 2012).

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